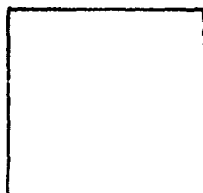


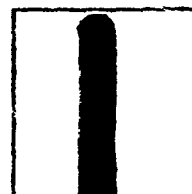
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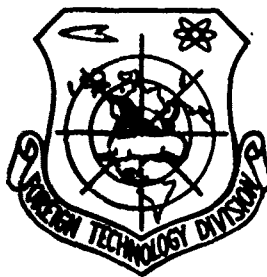
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## FOREIGN TECHNOLOGY DIVISION



METAL AND NON-METAL INORGANIC COATINGS. METHODS OF CHECKING



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FTD-ID(RS)T-0919-79

## EDITED TRANSLATION

FTD-ID(RS)T-0919-79 20 July 1979

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METHODS OF CHECKING

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FOREIGN TECHNOLOGY DIVISION  
WP.AFB, OHIO.

FTD-ID(RS)T-0919-79

Date 20 Jul 1979

# U. S. BOARD ON GEOGRAPHIC NAMES transliteration SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	<i>А а</i>	A, a	Р р	<i>Р р</i>	R, r
Б б	<i>Б б</i>	B, b	С с	<i>С с</i>	S, s
В в	<i>В в</i>	V, v	Т т	<i>Т т</i>	T, t
Г г	<i>Г г</i>	G, g	У у	<i>У у</i>	U, u
Д д	<i>Д д</i>	D, d	Ф ф	<i>Ф ф</i>	F, f
Е е	<i>Е е</i>	Ye, ye; E, e*	Х х	<i>Х х</i>	Kh, kh
Ж ж	<i>Ж ж</i>	Zh, zh	Ц ц	<i>Ц ц</i>	Ts, ts
З з	<i>З з</i>	Z, z	Ч ч	<i>Ч ч</i>	Ch, ch
И и	<i>И и</i>	I, i	Ш ш	<i>Ш ш</i>	Sh, sh
Й й	<i>Й й</i>	Y, y	Щ щ	<i>Щ щ</i>	Shch, shch
К к	<i>К к</i>	K, k	Ъ ъ	<i>Ъ ъ</i>	"
Л л	<i>Л л</i>	L, l	Ы ы	<i>Ы ы</i>	Y, y
М м	<i>М м</i>	M, m	Ь ь	<i>Ь ь</i>	'
Н н	<i>Н н</i>	N, n	Э э	<i>Э э</i>	E, e
О о	<i>О о</i>	O, o	Ю ю	<i>Ю ю</i>	Yu, yu
П п	<i>П п</i>	P, p	Я я	<i>Я я</i>	Ya, ya

\*ye initially, after vowels, and after ъ, ь; e elsewhere.  
When written as ě in Russian, transliterate as yě or ě.

## RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	sinh <sup>-1</sup>
cos	cos	ch	cosh	arc ch	cosh <sup>-1</sup>
tg	tan	th	tanh	arc th	tanh <sup>-1</sup>
ctg	cot	cth	coth	arc cth	coth <sup>-1</sup>
sec	sec	sch	sech	arc sch	sech <sup>-1</sup>
cosec	csc	csch	csch	arc csch	csch <sup>-1</sup>

Russian English

rot curl  
lg log

STATE STANDARD OF THE UNION SSR

GROUP V06

METAL AND NON-METAL INORGANIC COATINGS.  
METHODS OF CHECKING

GOST  
16875-71

To Replace

By the Decree of the State Committee  
of Standards, Council of Ministers, USSR  
from 6/IV/1971. No. 693

GOST 3247-46

GOST 3003-58

GOST 3265-46

GOST 3264-46

GOST 3263-46

Effective 1/VII/1972

Noncompliance with the standard will  
be prosecuted in accordance with the  
law

Official Publication

Reprinting is prohibited

This standard is expanded to cover metal and nonmetal inorganic coatings applied by the electrolytic, anodizing, and chemical methods and it established methods for checking them for correspondence with the requirements of GOST 3002-70.

The standard corresponds to the recommendations made by SEV [Council for Mutual Economic Aid (COMECON)] on the standardization of RS 2457-70, RS2458-70, RS 2459-70, RS 2460-70, and RS 2522-70.

#### 1. SAMPLING ORDER

1.1. The number of articles selected for checking is determined by GOST 3002-70.

1.2. When necessary, the areas of the surfaces of the articles on which the control measurements are made are stipulated in the

technical documentation with the article.

## 2. METHOD FOR CHECKING THE APPEARANCE OF COATINGS

2.1. The method is based on the detection of defects on the coating surface by visual examination and is applicable for articles of any shape and dimensions.

2.2. The check is performed by examining the articles with a naked eye in a room with the illumination of at least 300 lux.

The need for using optical devices with indicated magnification of power must be stipulated in the technical documentation for the article.

Recommended equipment: loupes of types LI-3, LI-4, and others as per GOST 8309-57 and GOST 7594-55.

Devices of various designs or samples are permitted for determining the degree of luster of the coatings.

The results of the external examination are recorded in a certificate.

## 3. METHODS FOR CHECKING THE THICKNESS OF COATINGS

### A. Physical Destructive Methods

3.1. Magnetic, electromagnetic, and radioactive methods and the eddy-current method.

3.1.1. The essence of these methods is based on the principle that, depending on the change in the coating thickness, the following changes occur:

magnetic method - in the force of separation of a permanent magnet from the surface of an article;

electromagnetic method - in magnetic flux arising between the converter of the instrument and an article;

radioactive method - in the intensity of the reflected beta radiation;

method of eddy currents - in the impedance transformer of the instrument, caused by the induction of eddy currents in the part.

3.1.2. Application and special features of these methods, depending on the material of a coating and the basic material, are indicated in Table 1.

3.1.3. In performing the measurements, it is permitted to use instruments (thickness gauges) of various designs with errors in percentages:

- magnetic method ...  $\pm 15$
- electromagnetic method ...  $\pm 10$
- radioactive method ...  $\pm 10$
- eddy current method ....  $\pm 10$ .

3.1.4. Before the measurements are made the articles are degreased in an organic solvent (bensine, trichloroethylene, etc.) or a paste made from magnesium oxide.

When the paste is used for degreasing, the samples are washed thoroughly by a stream of distilled water. These are dried in the air which is free of dust and oil or by means of a filter paper.

The degreasing process can be omitted when the check is made immediately after the coating has been applied.

The measurements are made in accordance with the instruction with the instrument.

3.1.5. Arithmetic mean of three measurement values is accepted as the measurement result.

#### B. Physical Destructive Methods

##### 3.2. Metallographic (microscopic) method

3.2.1. This method is based on the determination of the coating thickness on a cross section with magnification and is applicable for determining the local thickness of the single-layer and multi-layer electrolytic and anodized coatings, primarily as an arbitration method.

3.2.2. Metallographic microscopes of all types are permitted. Recommended magnifying powers: 500-1000 for coatings up to 20  $\mu\text{m}$  thick and 200 for coatings which are over 20  $\mu\text{m}$  thick.

3.2.3. To determine the coating thickness, thin sections with a cross cut of the coating (cross section) are prepared as indicated in attachment 1.

The surface of the thin section is degreased as instructed in Section 3.1.4 and, when necessary, it is etched. Solutions indicated in attachment 1 are used for etching.

The microscope for measurements is readied in accordance with the instructions for the instrument.

At least three measurements are made along the entire length of the section.

3.2.4. Arithmetic mean of three measurement values is used as the measurement result.

### 3.3. Weight method

3.3.1. This method is based on the determination of a mass of the applied coating and is used for determining the average thickness of the single-layer electrolytic and chemical coatings on parts whose mass is not over 200 g.

The relative error of this method is  $\pm 10\%$ .

3.3.2. In this case, equal-arm laboratory balance is used with an optical readout of the type VLR-200 as per GOST 15076-69. Other types of balance may be used, providing they have an accuracy up to  $\pm 0.001$  g.

3.3.3. The parts are degreased in accordance with Section 3.1.4.

3.3.4. The mass of the applied coating is determined by weighing the part on an analytical balance before and after the application.

3.3.5. The following formula is used to calculate the average thickness of the coating ( $H_{av}$ ) in micrometers:

$$H_{av} = \frac{(g_2 - g_1) \cdot 10000}{S \gamma}$$

where

$g_1$  - mass of the part before the application, g;

$g_2$  - mass of the part after the application, g;

$S$  - area of the coating surface,  $\text{cm}^2$ ;

$\gamma$  - density of the coating material,  $\text{g/cm}^3$ .

### B. Chemical Methods

#### 3.4. Jet, drop, and stripping methods

3.4.1. The jet method is based on the dissolution of a coating with a solvent flowing onto the surface of a part in the form of a jet at certain rate.



The thickness of the coating is calculated using the time it takes for the coating to dissolve (intermittent-jet method) or by the amount of the solvent spent to dissolve the coating (jet-test method).

The point at which the coating is dissolved is established visually or with the aid of an instrument, which records the change in the potential or the current at the moment of complete dissolution of the coating (electrojet method).

The drop method is based on the dissolution of a coating under the effect of the solution drops applied to the surface and which remain there for a certain period of time.

The thickness of a coating is determined using the number of drops it takes to dissolve the coating.

The stripping method is based on the dissolution of a coating in a solution which does not affect the metal of the part.

The coating thickness is calculated using the mass of the dissolved metal which is determined by two methods - by means of a chemical analysis of the solution or by weighing the part before and after the dissolution of the coating.

3.4.2. The jet and drop methods are used to measure the local thickness of the single-layer and multilayer metallic coatings indicated in Table 2, on the surfaces whose area is at least  $0.3 \text{ cm}^2$ . The jet method is not used for the parts whose contour prevents the draining of the solution.

The drop method is not recommended for use due to the large error and the duration of measurement, especially for coatings whose thickness is over  $20 \text{ }\mu\text{m}$ .

The stripping method is used to measure the average thickness of the single-layer and multilayer coatings of the parts having small dimensions, primarily it is used as an arbitration method. This method is not applicable for aluminum alloys of types AK4, AK4-1, and AK6, which contain copper and nickel.

The relative error is given below in percentages for each method, when determining the coating thickness from  $2 \text{ }\mu\text{m}$  and higher:

intermittent-jet method ...  $\pm 10$

jet-test method ...  $\pm 15$

drop method ...  $\pm 30$

stripping method ...  $\pm 10$ .

3.4.3. Before the measurements, the samples are degreased in accordance with Section 3.1.4.

Chromate and phosphate films from the zinc and cadmium coatings are removed by means of a cotton pad wetted with hydrochloric acid at a density of  $1.19 \text{ g/cm}^3$ , diluted at 1:8 ratio.

A drop of solution containing 5 g/l of copper sulfate is placed on the surface of a coating and is left there for 1 min to check if the chromate and phosphate films have been removed completely. The darkening of the surface indicates the absence of the chromate and phosphate films.

The dissolution of the chrome layer from the multilayer coatings is accomplished in a hydrochloric acid solution with a density at  $1.19 \text{ g/cm}^3$  with the addition of the antimony trioxide in the amount of 1-2 wt. %.

3.4.4. To prevent the test solution from spreading, the surface of the samples is isolated with any material that is chemically stable. In the case of the jet method, the isolation material is applied in the form of strips in parallel with the direction of run off of the solution, at a distance of approximately 4 mm from one another; in case of the drop method, a surface approximately 6 mm in diameter is isolated for the measurements.

Before the measurements, the samples and the test solutions are kept in the room until their temperature becomes the same as the environment.

It is recommended that the coating thickness be determined before any additional treatment (chromium plating, phosphate coating, etc.).

### 3.5. Intermittent-Jet Method

3.5.1. The apparatus shown in Fig. 1 is used for the measurements, which consists of a dropping funnel 5 with cock 6. A capillary tube 8, from which solution is delivered to the surface of sample 9, is connected to the lower end of the funnel by means of a rubber tube 7. The capillary tube is calibrated in such a way as to deliver  $10 \pm 0.1 \text{ ml}$  of distilled water in 30 s at  $18-20^\circ\text{C}$

and constant pressure, when cock 6 is open all the way.

Constant pressure is established by means of a glass tube 4 inserted through tube 3 into the neck of the funnel and having an opening 2 for air entering the funnel.

The lower end of the glass tube 4 must be in the solution at all times at a distance of  $250 \pm 5$  mm from the end of capillary tube 8. Thermometer 1 is inserted into tube 4.

The solutions used for these measurements are given in Table 2 and the instruction for their preparation in attachment 2.

3.5.2. The device is prepared for use as follows. Funnel 5 is filled three fourth with a prepared solution, capillary tube 8 is filled by opening cock 6. The neck of the funnel is plugged with a rubber stopper 3. Cock 6 is opened again and the solution is given a chance to flow out of the funnel until there is an even suction of air bubbles into the funnel through tube 4, which indicates that constant pressure is established.

Prior to the test, the flow rate of the solution from the capillary tube is checked, which must be the same as indicated in Section 3.5.1.

The apparatus prepared as described is secured by means of a laboratory stand in such a way that the end of the capillary tube is at a distance of 4-5 mm from the surface to be tested and that the angle between the axis of the capillary and the surface of the sample, or, in the case of a curvilinear surface tangent to this surface, is at  $45 \pm 5^\circ$ .

To prevent the solution from spreading and splashing, a glass rod, on which the solution should flow into a receptacle, is placed against the sample as close as possible to the area of testing.

3.5.3. To begin the measurement, cock 6 is opened and a stopwatch is started simultaneously; after a certain period of time, the cock is closed and the stopwatch is stopped, and the area where the stream fell is examined to see whether the color of the surface has changed. If there is no change in the color, the cock is opened again and the stopwatch is started. This process is repeated until the color changes at the location where the stream falls. The point at which the measurement is stopped is indicated

in Table 2.

During the subsequent measurements, when an approximate number of seconds is known during which a given coating dissolves, intervals between the measurements are as infrequent as possible. The number of seconds during which the stream flows is added.

When the thickness of the multilayer coatings is measured, the time it takes for each layer to dissolve is recorded separately and the thickness is calculated as shown below.

The temperature of the solution is recorded.

After the measurements are over, the apparatus is washed and filled with distilled water.

3.5.4. The local thickness of the coating ( $H_1$ ) is determined in micrometers, using the following formula:

$$H_1 = H_t \cdot t,$$

where

$H_t$  - thickness of a coating removed in 1 s, in  $\mu\text{m}$ ;

$t$  - time it takes to dissolve the coating, in s.

The quantity  $H_t$  is given in Table 3 for different coatings.

The following correction factors are introduced into the formula used to calculate the thickness: 1.35 for copper coatings from cyanide electrolytes; 0.7 for cadmium coatings from sulfuric acid electrolytes; 1.09 for the chromium lustrous coatings from sulfuric acid electrolytes; 1.2 for the chromium lustrous coatings from self-adjusting electrolytes; 1.04 for the chromium dull coatings from self-adjusting electrolytes; and 1.3 for the chromium dull coatings from tetrachromate electrolytes.

When calculating the thickness of nickel coatings from electrolytes with luster-forming additives, the coefficients given in Table 4 are introduced into the formula.

The arithmetic mean of three values obtained from the measurements is used as the measurement result.

### 3.6. Intermittent-Jet (Electrojet) Method

3.6.1. For these measurements the apparatus (Fig. 2) described in Section 3.5.1 is used, with the exception of the fact that a second glass tube 10, with a platinum wire 11 soldered in its

closed end, is inserted into the stopper 3, which plugs funnel 5. The lower end of the glass tube 10 must be in the solution at all times at  $250 \pm 5$  mm from the end of capillary tube 8.

The platinum wire and the sample being tested are connected to an electrical circuit, which includes current source 13 (dry-element battery of 3 V, as per GOST 2583-70 or GOST 3316-65), galvanometer 16 (null instrument), carbon fixed resistor 14 of type VS of 10 ohm, as per GOST 6562-67; variable carbon resistor 15 of type SP of 22 ohm, as per GOST 5574-65, and switch 12.

The electrical circuit can include a potentiometer of type R306, R307, as per GOST 9245-68, or millivoltmeter LPU-01 or LPM-60M-10.

An electrical system is permissible when the compensation method is used.

The apparatus is prepared in accordance with the instructions in Section 3.5.2.

The sample to be tested must be electrically insulated for a metallic stand.

3.6.2. When the measurements are made, the electrical system is turned on and the stopwatch is started when cock 6 is opened. The stopwatch is stopped and the cock is shut off at the moment the needle of the instrument deflects, which occurs when the coating is dissolved and the base metal or a sublayer appears.

3.6.3. The measurement results are processed in accordance with Section 3.5.4.

### 3.7. The Jet-test Method

3.7.1. These measurements are made by means of an apparatus consisting of a 50 ml buret (GOST 1770-64) graduated at 0.1 ml with glass cock, to which a capillary tube is connected by means of a rubber tube. The capillary tube is calibrated in such way as to deliver  $10 \pm 0.1$  ml of distilled water at  $18-20^\circ\text{C}$  in 30 s, when the cock is opened completely.

The solutions given in Table 2 are used for the measurements.

3.7.2. To perform the measurement, the cock is opened all the way to let out a stream of solution. After a certain period of time, the cock is closed and a check is made to see whether there

is a change in color of the surface at a point where the stream hits it. If there is no change in the color, the process is repeated until there is a change in color.

End of the measurement is established according to the change in color on the surface of the base metal or a sublayer (see Table 2).

When measuring the multilayer coatings, the amount of solution used to dissolve each layer is recorded individually, then these amounts are added, and the thickness of the coating is calculated as shown below.

The temperature of the solution is recorded.

3.7.3. The following formula is used to determine the local thickness of the coating ( $H_1$ ) in micrometers:

$$H_1 = H_v \cdot V,$$

where

$H_v$  - thickness of the coating removed with  $v$  ml of solution, in  $\mu\text{m}$  (see Table 5);

$V$  - amount of solution used to dissolve the coating, in ml.

The arithmetic mean of three measurement values is accepted as the measurement result.

The following correction factors are introduced into the formula used to calculate the thickness: 0.7 for the cadmium coatings from sulfuric acid electrolytes and 1.35 for the copper coatings from cyanide electrolytes.

### 3.8. Drop Method

3.8.1. A drop is applied from a dropper with the internal diameter of the end of the capillary at 1.5-2.0 mm onto the surface of a coating and left there for a certain period of time. Then this drop is blotted dry with a filter paper, after which, a second drop of the solution is placed on the same spot. This process is repeated until the base metal or a sublayer appears, or a spot of a contact-isolated metal.

The solutions used for the measurements, time the drop remains on the surface, and the point at which the measurement is terminated are indicated in Table 6.

3.8.2. The following formula is used to calculate the local

thickness of the coating ( $H_1$ ) in micrometers:

$$H_1 = H_k(n - 0.5),$$

where

$H_k$  - thickness of coating removed by one drop of solution in a given period of time, in  $\mu\text{m}$  (see Table 7);

$n$  - number of drops used to dissolve the coating.

The arithmetic mean of three measurement values is accepted as the measurement result.

### 3.9. Stripping Method

3.9.1. These measurements are made in two ways:

a) the part is weighed and immersed into an appropriate solution; after the coating of the part is dissolved, it is removed from the solution, washed, dried, and weighed.

The following formula is used to determine the coating thickness ( $H_{av}$ ) in micrometers:

$$H_{av} = \frac{(g_1 - g_2) \cdot 1000}{\gamma S}$$

where

$g_1$  - mass of the part before the coating was stripped, g;

$g_2$  - mass of the part after the coating was dissolved, g;

$\gamma$  - density of metal coating,  $\text{g/cm}^3$ ;

$S$  - surface area of the sample,  $\text{cm}^2$ ;

b) the part is immersed into an appropriate solution; after the coating is dissolved, the part is removed from the solution and washed several times with distilled water. The solution is combined with the water that has been used for washing and then transferred to a flask up to a mark and the liquid is analyzed for the content of the dissolved metal.

The solutions for removing the coating are given in Table 8.

The following formula is used to determine the average coating thickness ( $H_{av}$ ) in micrometers:

$$H_{av} = \frac{P \cdot 10000}{\gamma S},$$

where  $P$  - mass of metal obtained by chemical analysis, in g.

STOP HERE



#### 4. METHODS FOR CHECKING THE POROSITY OF COATINGS

##### 4.1. Paste Method

4.1.1. The method is based on chemical interaction of the base metal or a sublayer with the reagent in the areas of pores and other breaks in the coating with the formation of colored compounds.

This method is used to determine the porosity of the cathode-type metallic coatings on steel, copper, aluminum, zinc, and their alloys and of the inorganic nonmetal coatings on aluminum and its alloys, on articles having any shape and dimensions.

4.1.2. The following items are used:

hair brushes as per GOST 10597-70 (various pulverizers can be used);

pastes. The composition of pastes is given in Table 9. The method of preparation is given in attachment 3.

4.1.3. The articles are degreased as per the instructions in Section 3.1.4.

The paste is applied to the surface of a coating by means of the brush, pulverizer, immersion, or some other method, which ensures an application of a uniform layer of the paste which is left on for 10 min.

The application of a paste is at  $0.5-1.0 \text{ g/dm}^2$ .

After the check is made, the paste is removed by washing the article by running distilled water, then it is dried and the process is repeated at the same area of the surface.

4.1.4. The number of colored sections corresponding to the number of pores are counted on the test surface of the coating.

The arithmetic mean of the values of three measurements is used as the measurement result. The obtained porosity is applied to a unit of the surface area.

##### 4.2. Method of Filter Paper Application

4.2.1. This method is based on chemical interaction of the base metal or a sublayer with the reagent in the areas of pores and other discontinuities in the coating with the formation of colored compounds.

This method is used for determining the porosity of the cathode-type metallic coatings on steel, copper, and its alloys, on



articles with a simple form, when the contour of the article permits the application of filter paper.

4.2.2. The articles are degreased in accordance with Section 3.1.4.

Filter paper, which has been saturated with an appropriate solution indicated in Table 10, is placed over the prepared surface of an article. The paper is applied in such a way as not to leave any air bubbles between the surface of the article and paper. The paper with an imprint of pores in the form of dots or spots is removed and washed with a stream of distilled water and dried on clean glass.

The solutions used for the determination and the test regimes are given in Table 10.

To detect the pores which extend to copper or brass, after washing, the filter paper with an imprint of pores is placed on a clean glass and a solution of potassium cyanide (40 g/l) is applied evenly over it. This treatment results in the disappearance of yellow spots (traces of nickel); after this, the paper is washed with a stream of water and dried on the glass. The dark-red and blue spots (traces of pores extending to copper and steel) remaining on the paper are counted.

In order to detect pores which extend down to nickel, the filter paper with an imprint of pores is placed over clean glass and an ammonia solution of dimethylglyoxime (dimethylglyoxime - 2 g/l and 25% ammonia - 500 ml/l) is applied evenly over it. After the bright-pink dots or spots, characteristic for nickel, are formed in the areas of pores, the filter paper is washed with a stream of water and dried on the glass.

During this process the traces of pores extending to steel and copper fade and do not interfere with the counting of the pores extending to nickel.

The determination of the porosity of the coatings with an upper chromium layer is performed not earlier than 30 min after the chromizing process. In the case of very porous chromium coatings on the copper-plated steel, copper and its alloys, the traces of pores extending to copper and brass are not shown clearly on the

paper and the dark-red spots have to be counted on the article itself.

These traces of pores should be visible with a naked eye.

4.2.3. The number of pores is determined as follows.

The filter paper with the imprint of pores is placed on a glass, which is divided into square centimeters. The number of pores is counted in each square. The numbers obtained from each square are added. The area of the paper in contact with the part is measured and the number of pores per unit of surface area is determined.

## 5. METHOD FOR TESTING THE ADHESION STRENGTH OF COATINGS

5.1. These methods are based on the difference between the physicomachanical properties of the coating metals and the base metal of a component.

5.2. The test methods are selected depending on the metal of the coating, type, and purpose for which the part was designed.

5.3. Various types of equipment and devices can be used for these tests (polishing and scratch-brushing machines, muffle furnaces, vice, etc.).

### 5.4. Polishing Method

5.4.1. The surface of a coating is polished for at least 15 s. Discs made out of coarse calico, felt, and other materials are used for polishing; the pastes - crocus, chromium, and others.

Polishing rate - 20-30 m/s.

There should not be any swelling or separation of the coating after polishing.

### 5.5. Scratch-brushing Method

5.5.1. The coating surface is subjected to scratch brushing for at least 15 s.

The scratch-brushing method employs steel and brass brushes (for soft coatings) with the diameter of the wire at 0.1-0.3 mm and the speed of rotation at 1500-2800 rpm.

After this treatment, the surface that was tested must not show any swelling or separation of the coating.

### 5.6. Heating Method

5.6.1. The coated articles are heated for 0.5-1.0 h and then cooled in air.

The heating temperature for the articles with all types of coatings, with the exception of zinc, cadmium, tin, lead, and tin-lead alloys, is given in Table 11.

Table 11

Base metal	Heating temperature, °C
Aluminum and its alloys	190 $\pm$ 5
Magnesium and its alloys	125 $\pm$ 5
Copper and its alloys	250 $\pm$ 5
Steel and cast iron	350 $\pm$ 5
Titanium and its alloys	210 $\pm$ 5
Zinc and its alloys	140 $\pm$ 5

Note: It is permitted to reduce the heating temperature for the articles which have seams soldered with solders whose melting point is lower than the heating temperature shown in Table 11.

For the zinc and cadmium coatings, the heating temperature must be between 180 and 200°C; for the tin, lead, and tin-lead alloy coatings - 140-160°C.

The article that was tested should not show any swelling or separation of the coating after heating.

#### 5.7. Winding Method

5.7.1. This method is used to determine the adhesive strength of coatings on wire.

Wire with a diameter up to 1 mm is wound onto a rod with a specified diameter; wire with a diameter greater than 1 mm is wound around the wire of the same diameter in such a way as to form 10-15 closely wound turns.

The springs whose diameter of the wire is up to 1 mm are tested by straightening; with the diameter over 1 mm - by stretching the springs to their double length.

After testing, there should not be any separation of the coating on the surface of the coating.

#### 5.8. A Method Utilizing a Network of Scratches

5.8.1. Using a sharp steel point, 4-6 parallel lines cut right through to the base metal are made on the test surface of the coating at 2.0-2.5 mm from one another and 4-6 parallel lines perpendicular to the other. The lines should be made in the same direction.

The surface being tested must not show any separation of the coating.

#### 5.9. Bending Method

5.9.1. The coated articles are subjected to bending at a 90° angle in both directions up to a fracture.

There must not be any separation of the coating at the point of fracture.

### 6. METHODS FOR CHECKING THE PROTECTIVE ABILITY OF NONMETALLIC AND NONORGANIC COATINGS

6.1. The drop and immersion methods are based on the destruction of a coating under the effect of the test solutions. The evidence indicating that the coating is destroyed is a contact precipitation of copper on the base metal or a change in color of the solution drop, caused by the interaction between the base metal and solution, or the formation of the products of corrosion.

The oxide and phosphate coatings are tested before saturation.

The anodized oxide coatings on aluminum with fillers are tested not later than 3 h after filling.

6.2. The following items are used for this test:

dropper as per GOST 9876-61;

stopwatch as per GOST 5072-67;

solutions used for testing the protective ability of coatings are given in Table 12.

6.3. The articles are degreased as indicated in Section 3.1.4.

#### 6.4. Drop Method

6.4.1. To test the protective ability of the anodized and oxide coatings on aluminum and its alloys, 1-2 drops of solution #30 are applied to the surface of the coating. The determination

period is timed with a stopwatch.

The time norms for the drop test are indicated in Table 13.

During the period indicated there should not be any change in color of the drop (from orange to green).

To test the protective ability of the phosphate coatings, one drop of solution #31 is applied to the coating from a dropper and a change in color is observed from blue to yellow, light green, or red. The moment at which the color changes is established by means of a stopwatch.

The resistance norms of the phosphate coatings are given in Table 14.

TABLE 14

Time before the color of the drop changes, in min	Coating resistance norm
Over 5	Highest
5	Normal
2-4	Average
Under 1	Lowest

#### 6.5. Immersion Method

6.5.1. To test the protective ability of the oxide coatings on steel, the samples are immersed into solution #29 at 15-25°C for 30 s. After this, the samples are removed from the solution, washed in distilled water, and dried with a filter paper.

The test surface should not show any spots - contact precipitation of copper.

It is permissible to test with a drop method using the same solution.

The properties of the phosphate coatings on steel, intended to contain oils and lubricants, are checked by immersing the part into solution #32 at 20±5°C for 15 min.

At the end of 15 min, the part is removed from the solution, washed, and dried.

The protective properties of the phosphate coatings on steel, intended for the paint-and-varnish or plastic coatings, are tested

by immersing the article into solution #33 at  $20 \pm 5^\circ\text{C}$  for 5 min.

At the end of this period, the article is removed from the solution, washed, and dried.

At the end of one hour, the articles are examined with a naked eye.

One should not observe any corrosion of the base metal on the test surface.

## 7. METHODS FOR CHECKING THE SPECIAL PROPERTIES OF COATINGS

7.1. The methods for checking the special properties of coatings are given in attachment 4.

## 8. REAGENTS AND MATERIALS

8.1. Reagents and materials used for testing the coatings are given in attachment 5.

Recommended Attachment 1 to GOST 16875-71

## INSTRUCTIONS FOR PREPARING A THIN SECTION

The sample for a section is cut from an article in such a way as to have the plane of the coating strictly perpendicular to the plane of the section.

In order to preclude the destruction of a coating while obtaining a section, a special protective metal layer 20-30  $\mu\text{m}$  thick is formed, which has a good strength of adhesion with the coating to be tested and which is relatively hard.

It is permissible to pour the section by means of fusible alloys (Rose's alloy, Wood's alloy, etc.) or such materials as shellac, organic glass, sulfur, and other.

The materials for the pouring of a sample with a coating must have:

a) sufficient mechanical strength.

During subsequent grinding and polishing of the sample, the destruction of the filling material is not permitted and it should not be rubbed any harder than the coating material;

b) limited melting point.

The smearing of the filling material is not permitted during

polishing, which is accompanied by heating.

During pouring, the sample is placed vertically into a metal ring. The metal ring is placed on plane mirror glass and the sample is secured by means of some clamp such that it coincides with its mirror image.

When flat samples are used, the pouring can be omitted.

In this case the sample is secured by means of metallic jaws. Intermediate pieces made out of soft metal (aluminum or copper) are placed on each side of the sample to protect it against compression.

When the sections are prepared, it is recommended that the grinding and polishing be performed at a  $45^\circ$  angle to the coating.

To prevent the smearing of metals, it is recommended that the grinding and polishing be done at a  $45^\circ$  angle to the coating during the preparation of samples.

The process begins with the sample being worked with a rough file, with a subsequent change to a barette file. After this, it is worked with a sandpaper, changing from coarse to fine.

When going from one type of sandpaper to the next, care is taken to remove the polishing dust, since the dust from the preceding phase causes scratches on the section during subsequent treatment. In going from one phase to the next, the direction of motion should be varied.

The final phase - polishing - is performed using a felt or a wool disc with the aid of the chromium, aluminum, or magnesium oxide paste, depending on the material being studied.

Recommended Attachment to GOST 16875-71

#### PREPARATION OF SOLUTIONS

Solutions # 1, 2, 5, 7, 8, 10, 13, 15, 16, 17, 18, 19, 21, 22, 24, 25, 26, 27, 28, 29, 30, 32, and 33 are prepared by dissolution in distilled water.

Solutions 3 and 9

300 g of ferric chloride are dissolved in 200-300 ml of distilled water and 100 g of copper sulphate are dissolved in the



same amount of distilled water at 50–60°C. After cooling, both solutions are transferred into a 1 l measuring flask and the volume of the solution is brought up to the mark, then the solution is filtered.

#### Solution 4

A batch of 60 g of ferric chloride is dissolved in 200 ml of distilled water and 30 g of copper sulphate are dissolved in the same amount of water separately at 50–60°C. After cooling, both solutions are transferred into a 1 l measuring flask; to this flask are added 220 ml of hydrochloric acid and 100 ml of sulfuric acid with the specific gravity of 1.19 and 1.84, respectively. After the solution is cooled, it is brought up to the mark with the distilled water.

#### Solution 6

150 g of ferric chloride are dissolved in 500 ml of distilled water and 31 g of antimony trichloride are dissolved separately in 150 ml of hydrochloric acid. Both solutions are transferred to a 1 l measuring flask, 250 ml of acetic acid are added, and the total volume is brought to the mark.

#### Solution 11

50 ml of ferric chloride are dissolved in 150 g of 1N hydrochloric solution and 20 g of copper sulphate are dissolved in 300 ml of distilled water separately. Both solutions are transferred to a 1 l measuring flask and the volume is brought up to the mark.

#### Solutions 12 and 20

50 ml of distilled water are added to 62 g of boric acid to obtain a homogeneous thick mass. Then, hydrofluoric acid is added with constant mixing until the boric acid is completely dissolved. It takes 175 ml of hydrofluoric acid with a specific gravity at 1.13 for 62 g of boric acid. This solution is prepared in a vessel made out of organic material.

An aqueous solution of fluoboric acid (1:10) and hydrogen peroxide (30%) are used for the chemical stripping of a coating and for the drop method at 2.5 ml to 100 ml of diluted acid. Hydrogen peroxide is added just before use.

#### Solution 14



2000 g of ammonium nitrate are dissolved in 1 l of distilled water with mixing and heating up to 40°C. Then the solution is filtered.

#### Solution 23

135 g of sodium hydroxide are dissolved in 500 ml of distilled water and 80 g of lead acetate are dissolved in 500 ml of distilled water separately. Then the solution of lead acetate is added in small amounts to sodium hydroxide with mixing, first at room temperature and then with heating until complete dissolution.

#### Solution 31

82 g of copper sulphate and 33 g of sodium chloride are dissolved separately in small volumes of distilled water. Both solutions are transferred to a 1 l measuring flask, to this are added 13 ml of 0.1N solution of hydrochloric acid, and the volume is brought up to the 1 l mark.

Recommended Attachment 3 to GOST 16875-71

### INSTRUCTIONS FOR PASTE PREPARATION

1. Paste for determining the porosity of coatings on parts made of steel.

A weighted sample of  $\alpha$ - $\alpha$ -dipyridyl or 0-phenanthroline in the amount of 1-2 g are dissolved in 100 ml of 0.1-0.2N hydrochloric acid solution.

Then titanium dioxide is added to this solution, calculated at 10-15 g for 10 ml of solution. This mixture is mixed thoroughly until a homogeneous mass is formed. This paste should be used within 10 to 14 days.

When this paste is used for longer period of time, it may get contaminated with iron compounds.

2. Paste for determining the porosity of coatings on copper and its alloys.

#### Composition #1

A 20% solution of diphenylcarbazide is prepared in glacial acetic acid (solution 1) with heating on a water bath. Then titanium dioxide is added to this warm solution (until the pre-

precipitation of diphenylcarbazine), calculated at 15-30 g for 10 ml of solution. Then a solution of ammonium persulfate in ammonia, obtained by dissolving 10 g of ammonium persulfate in 100 ml of a 100% solution of ammonia (solution 2), and glycerine is added to this mixture. The mixture is mixed thoroughly with the addition of each component. The ratio of the volumes of solutions 1 and 2 is equal to (1-3):(3-1) and the glycerine volume must equal to 1/4 of the sum of the volumes of solutions 1 and 2.

An optimum ratio for the volumes of solutions 1 and 2 and glycerine is 1:1:0.5.

The paste is good for 2 to 3 days.

#### Composition #2

A preparation is made of a 2% aqueous solution of cadion II (solution 1) and solution of ammonium persulfate in ammonia, containing 5-15 g of ammonium persulfate and 5-20 ml of ammonia (specific gravity of 0.91) for 100 ml of solution (solution 2).

Solutions 1 and 2 are mixed in a 1:1 ratio. Titanium dioxide is added to this solution, calculated at 12-15 g for 10 ml of solution. The mixture is mixed thoroughly until a homogeneous mass is obtained.

This paste is good for 3-4 days.

3. Paste for determining the porosity of coatings on parts made out of aluminum and its alloys.

A 2% aqueous solution of aluminum is prepared. To this solution, titanium dioxide is added in the amount of 15-20 g for 10 ml of solution and 20-25% solution of hydrogen peroxide with the density of 1.14-1.15. The ratio of the volumes of the aluminum and hydrogen peroxide solutions is 1:0.5. The mixture is mixed thoroughly until a homogeneous mass is obtained.

The paste is good for 3-4 h.

4. Paste for determining the porosity of coatings on articles made out of zinc and its alloys.

A solution of diphenylthiocarbazine is prepared in ethyl or propyl alcohol, containing 0.5 g of diphenylthiocarbazine in 100 ml of alcohol (solution 1) and 0.5N solution of sodium hydroxide (solution 2).

To the obtained solution 1, titanium dioxide is added in the amount of 20-30 g for 10 ml of solution. Solution 2 is added to this mixture. The ratio of the volumes of solutions 1 and 2 is equal to 1:2. This mixture is mixed thoroughly until a homogeneous mass is obtained,

This paste is good for 3-4 days.

Recommended Attachment 4 to GOST 16875-71

#### METHODS FOR TESTING THE SPECIAL PROPERTIES OF COATINGS

##### 1. Method for Checking Microhardness

The microhardness of coatings is tested in accordance with GOST 9450-60.

##### 2. Method for Testing the Specific Electrical Resistance of Coatings.

2.1. This method is based on the measurement of the specific electrical resistance of a coating by means of an electric-measuring bridge.

This method is used to determine the specific electrical resistance of any metal coatings.

2.2. Single-double electrical measuring bridge of the type MOD-54 is used for measurements in the range from  $10^{-5}$  -  $10^5$  ohm, with an accuracy class of 0.05 as per GOST 7165-66.

Other types of instruments may be used, if they have the same range and accuracy.

2.3. The coating to be checked is deposited onto a wire 0.1 mm thick and 0.2-0.5 m long, consisting of a material with high electrical resistance (constantan). To improve the adhesion between the coating and the base metal, it is permissible to apply a sub-layer of copper, nickel, and other.

The wire's length and diameter are measured before and after the application of coating by means of an optical caliper of type IKG as per GOST 5405-64.

The wire is degreased as indicated in Section 3.1.4 of this standard.

The wire with the coating to be tested is connected to the

corresponding terminals of the bridge for measuring resistance. The resistance of the base metal with and without the coating. The determination is performed in accordance with the instructions with the instrument.

It is permissible to make measurements using a sample representing a metal coating separated from the base metal.

2.4. The specific resistance  $\rho$  is determined in  $\text{ohm}\cdot\text{mm}^2/\text{m}$ , using the formula:

$$\rho = \frac{R_h \cdot S}{l},$$

where

$S$  - cross section of the coating,  $\text{mm}^2$ ;

$l$  - length of the wire segment being measured, m;

$R_h$  - resistance of the coating, ohm.

The coating resistance  $R_h$  is determined by the following formula in ohms:

$$R_h = \frac{R_{\text{total}} \cdot R_{\text{base}}}{(R_{\text{base}} - R_{\text{total}})},$$

where

$R_{\text{total}}$  - total resistance of the base metal with coating, ohm;

$R_{\text{base}}$  - resistance of the base metal (taking into account the sublayer), ohm.

The cross section of the coating  $S$  is determined by the following formula in  $\text{mm}^2$ :

$$S = \frac{\pi}{4}(D_1^2 - D_2^2),$$

where

$D_1$  - diameter of the wire with coating, mm;

$D_2$  - diameter of the wire without coating, mm.

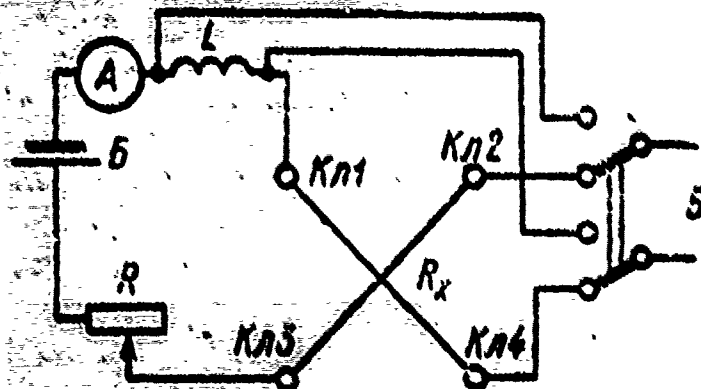
The arithmetic mean of three measurement values is used as the measurement result.

### 3. Method for Checking the Contact Electrical Resistance of the Coating.

3.1. This method is based on the determination of the contact resistance of a point contact of two conductors made from copper and its alloys, coated with the metal being tested.

This method is used to measure the contact electrical resistance of metal coatings.

The drawing shows the diagram of the device.



A diagram of the device for determining the contact electrical resistance of metallic coatings.

3.2. To determine the contact resistance, the coating to be tested is applied onto a wire made of copper or its alloys which is 1 mm in diameter.

The sample is degreased before testing.

3.3. The sample is connected to the device consisting of the direct-current source Б, ammeter, reference coil as per GOST 6864-69, and rheostat by means of the connectors Kn1, Kn2, Kn3, and Kn4.

The load to the upper or lower wire is varied by means of a special device. Drop in voltage is determined at the point of contact and at the terminals of the reference coil by means of the potentiometers of types R306, R307 as per GOST 9245-68. The load at the contact and the current strength are established depending on the requirements for contact. The recommended loads for the determination of the contact electrical resistance are 10, 20, 50, and 100 g at 50 mA. The determination is made at 18-25°C and relative humidity of the air at 47-75%. The measurements are taken in accordance with the instructions accompanying the instrument.

3.4. The contact electrical resistance  $R_x$  is determined by

the following formula in ohms:

$$R_x = \frac{\Delta E}{I},$$

where

$\Delta E$  - drop in voltage at the contact, mV;

$I$  - current strength in the circuit, mA.

The current strength  $I$  in the circuit is determined by the following formula in milliamperes:

$$I = \frac{\Delta E_1}{R_{re}},$$

where

$\Delta E_1$  - drop in voltage at the coil's terminals, mV;

$R_{re}$  - resistance of the reference coil, ohm.

The recommended values for  $R_{re}$  are 0.1-1.0 ohm.

The arithmetic mean of three measurement values is accepted as the measurement result.

4. Method for determining the electrical breakdown voltage.

4.1. This method is based on an electrical breakdown in a dielectric layer under the effect of applied electrical voltage.

This method is used for measuring the breakdown voltage in nonmetal electrical insulating coatings (anodized oxide coatings on aluminum and its alloys).

4.2. A device of type UPU-1 as per MRTU TU AE2-771-001 is recommended for the determination of the breakdown voltage.

Devices of various designs are permitted.

It is recommended that the measuring electrodes be made from a solid alloy with the roughness of the working surfaces not lower than  $\nabla 7$  as per GOST 2789-59 and the curvature radius of 1.5 mm.

4.3. The samples are degreased before testing.

4.4. The voltage is determined in two ways:

a) electrical insulation coating is removed from a small area on the sample and one of the electrodes is placed at the cleared spot, while the second electrode - to the coating being tested. The voltage, at which a breakdown occurs, is equal to the voltage

recorded by the instrument;

b) the determination is made without damaging the electric insulation coating. The electrodes are arranged at a distance of 2-3 cm from one another. The breakdown occurs at two points of the electrical insulation coating. The magnitude of the breakdown voltage is equal to half of that recorded by the instrument.

The pressure of the measuring electrode, where it comes in contact with the surface of the coating being tested, must not exceed 50-75 g at the moment of determination. The electrodes should be secured in a grounded head (holder).

The measurements are made at a voltage, which increases continually from 0 to the specified measurement limits. The voltage increase rate should not exceed 25 V/s.

The measurement is made at 15-35°C and at a relative humidity of the air at 45-75% no sooner than 1 h after anodization.

The arithmetic mean of five measurement values is accepted as the measurement result.

#### 5. Method for Determining Oil Absorption

5.1. This method is based on the determination of the amount of oil adsorbed by a coating.

This method is used for determining the oil absorption of the phosphate coatings on parts whose surface is at least 30 cm<sup>2</sup>.

5.2. This method employs oil whose viscosity is at 25-35° cSt at 25°C.

5.3. A coated sample is weighed, immersed into oil at 130°C, and is left there until the oil cools to 20±5°C; after this, the sample is removed from the oil, the excess is removed with a filter paper, and it is weighed again.

During weighing, the temperature must be constant.

The weighing is performed with an accuracy to 0.0001 g.

The amount of oil adsorbed by the coating is determined by the difference in the mass of the sample before and after the oil treatment.

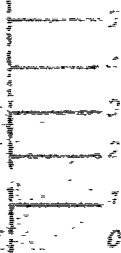
5.4. Oil absorption M is determined by the following formula in ml/cm<sup>2</sup>:

$$M = \frac{b - a}{F},$$

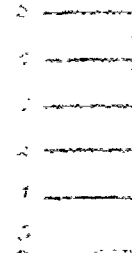


where

- a - mass of the sample before the immersion, mg;
- b - mass of the sample after the immersion, mg;
- F - sample's surface area,  $\text{cm}^2$ .



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## REAGENTS AND MATERIALS USED FOR TESTING COATINGS

(1) Наименование	(2) Химическая формула	(3) Номер стандарта или ТУ
Алюминий	$C_{10}H_{11}O_3(COONH_4)_3$	ГОСТ 9859-61
Аммоний азотнокислый	$NH_4NO_3$	ГОСТ 3761-65
Аммоний сернокислый	$(NH_4)_2SO_4$	ГОСТ 3769-60
Аммоний надсернокислый (персуль- фат аммония)	$(NH_4)_2S_2O_8$	ГОСТ 3766-64
Аммоний хлористый	$NH_4Cl$	ГОСТ 3773-60
Аммиак водный 25%-ный	$NH_4OH$	ГОСТ 3760-64
Ангидрид хромовый	$CrO_3$	ГОСТ 2548-69
Ацетон	$CH_3COCH_3$	ГОСТ 2603-63
Бензин авиационный	—	ГОСТ 1012-54
Водорода перекись	$H_2O_2$	ГОСТ 10929-64
Глицерин	$C_3H_5(OH)_3$	ГОСТ 6259-71
Дифенилтиокарбазид	$C_{13}H_{14}SN_4$	МРТУ 6-09- 2098-65
$\alpha$ - $\alpha$ - дипиридил	$C_{10}H_8N_2$	МРТУ 6-09- 3707-67
Дифенилкарбазид	$C_{13}H_{14}ON_4$	ГОСТ 5859-51
Железо хлорное	$FeCl_3 \cdot 6H_2O$	ГОСТ 4147-65
Под	J	ГОСТ 4159-64
Кадмий II или кадмий ИРЕА (ди- натриевая соль <i>m</i> -нитродиазоаминоа- зобензол-дисульфокислоты)	$C_{18}H_{12}O_8N_6S_2Na_2$	ВТУ РУ 1307- 56
Калий азотнокислый	$KNO_3$	ГОСТ 4217-65
Калий двуххромовокислый	$K_2Cr_2O_7$	ГОСТ 4220-65
Калий железистосинеродистый	$K_4[Fe(CN)_6] \cdot 3H_2O$	ГОСТ 4207-65
Калий железосинеродистый	$K_3[Fe(CN)_6]$	ГОСТ 4206-65
Калий йодистый	KJ	ГОСТ 4232-65
Кислота азотная	$HNO_3$	ГОСТ 4461-67
Кислота борная	$H_3BO_3$	ГОСТ 9656-61
Кислота фтористоводородная (тех- ническая)	HF	ГОСТ 2567-54
Кислота соляная	HCl	ГОСТ 3118-67
Кислота серная	$H_2SO_4$	ГОСТ 4204-66
Кислота фосфорная	$H_3PO_4$	ГОСТ 6552-58
Кислота уксусная	$C_4H_4O_6$	ГОСТ 5817-69
Кислота уксусная (ледяная)	$CH_3COOH$	ГОСТ 61-69
Кислота сульфаминовая	$H_2NSOH$	МРТУ 6-09- 926-63
Кислота пикриновая	$[HO_2C_6H_2(NO_2)_3]$	РТУ 26-55 (разовые) [one time]

KEY: (1) Items (2) Chemical formula (3) Number of the standard  
or TU [Technical Specifications]

## Continuation of Attachment 5

Медь сернокислая	$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$	ГОСТ 4165—66
Магния окись	$\text{MgO}$	ГОСТ 4526—67
Натр едкий	$\text{NaOH}$	ГОСТ 4328—66
Натрий хлористый	$\text{NaCl}$	ГОСТ 4223—66
Натрий серноватистокислый (тио- сульфат натрия)	$\text{Na}_2\text{S}_2\text{O}_3$	ГОСТ 4215—66
Натрий сернокислый	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$	ГОСТ 6318—66
Натрий надсернокислый	$\text{Na}_2\text{S}_2\text{O}_8$	МРТУ 6—09— 840—63
Серебро азотнокислос	$\text{AgNO}_3$	ГОСТ 1277—63
Свинец уксуснокислый	$\text{Pb}(\text{CH}_3\text{COO})_2 \cdot 3\text{H}_2\text{O}$	ГОСТ 1027—67
Спирт этиловый технический (гид- ролизный) (марка А)	$\text{C}_2\text{H}_5\text{OH}$	ГОСТ 8314—57
Спирт пропиловый	$\text{C}_3\text{H}_7\text{OH}$	СТ ГОХП15
Сурьма треххлористая	$\text{SbCl}_3$	МРТУ 6—09— 2289—65
Титана двуокись ( <i>finely pulverized</i> (тонкобразтертая))	$\text{TiO}_2$	ТУ МХП 3052— 51
(4) О-фенатролин	—	ТУ МХП 3461— 53
(5) Паста ГОИ	—	СТУ 30—12246 —61
(6) Сплав Вуда	—	ТУ МХП 3348— 52
(7) Сплав Розе	—	ТУ МЭП 3151— 52
Трихлорэтилен	$\text{C}_2\text{HCl}_3$	ГОСТ 9976—70
Сера техническая	—	ГОСТ 127—64
Бумага шлифовальная № 3—12	—	ГОСТ 3647—59
Бумага фильтровальная	—	ГОСТ 12026—66
Вата гигроскопическая	—	ГОСТ 5556—66

KEY: (4) O-phenanthroline (2) [O-phenanthroline] (5) GOI Paste  
 (6) Wood's alloy (7) Rose's Alloy (8) Sulfur, technical  
 (9) Sandpaper #3-12 (10) Filter paper (11) Gygroscopic  
 cotton

TABLE 1

## Methods Employed Depending on the Material of the Coating

(3) Основной материал	Применяемые методы в зависимости от материала покрытия		
	(1) токопроводящего		(2) нетокопроводящего
	(4) немагнитного металлического	(5) магнитного металлического	(6) неметаллического неорганического
(7) Магнитный (сталь, чугун, никель)	(8) Магнитный, электромагнит- ный, радиоактив- ный	(8) Магнитный, электромагнит- ный, радиоактив- ный	(7) Магнитный, электромагнит- ный, радиоактив- ный, метод вихре- вых токов
(10) Немагнитный токопроводящий (алюминий, медь и др.)	(11) Метод вихревых токов, радиоактив- ный	(11) Метод вихревых токов, радиоактив- ный	(11) Метод вихревых токов, радиоактив- ный
(12) Немагнитный нетокопроводя- щий (керамика, пластмасса)	(11) Радиоактив- ный, метод вихре- вых токов	(8) Магнитный, электромагнит- ный, радиоактив- ный	—

KEY: (1) Current conducting (2) Does not conduct current (3) Base material (4) Nonmagnetic, metallic (5) Magnetic, metallic (6) Nonmetal, nonorganic (7) Magnetic (steel, cast iron, nickel) (8) Magnetic, electromagnetic, radioactive (9) Magnetic, electromagnetic, radioactive, eddy-current method (10) Nonmagnetic, current conducting (aluminum, copper, etc.) (11) Eddy current method, radioactive (12) Nonmagnetic, does not conduct current (ceramics, plastics)

Fig. 1.

A diagram of the device  
for the intermittent-jet  
method

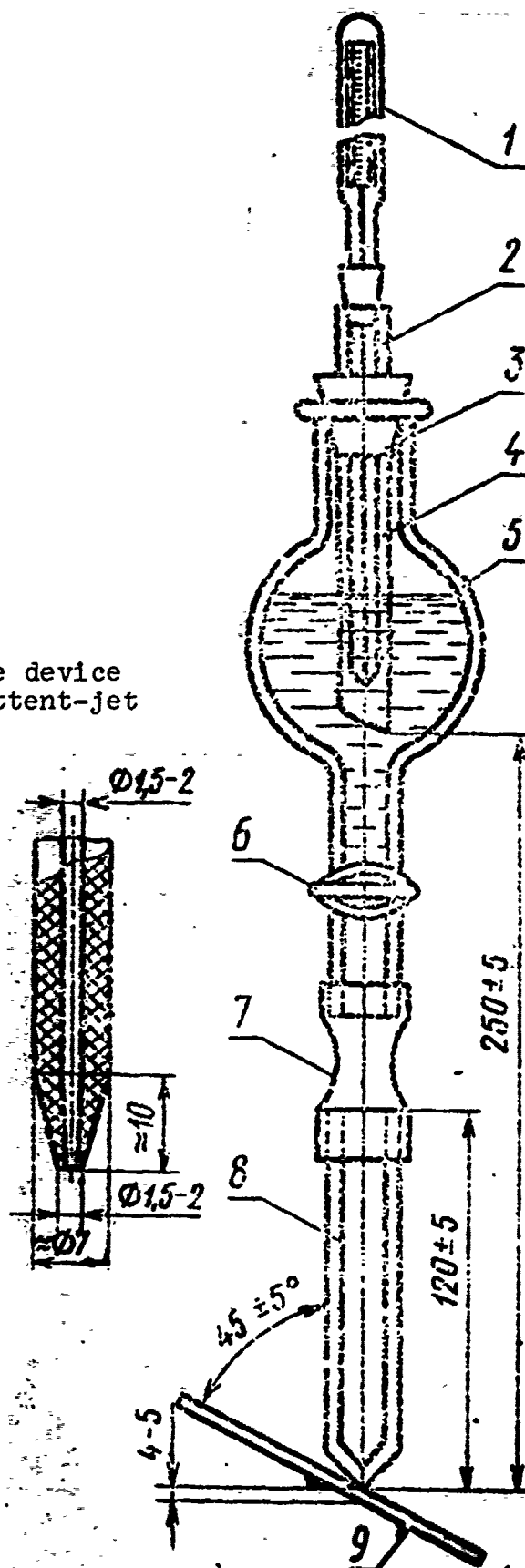


TABLE 2

(1) Вид покрытия	(2) Основной металл или металл подслоя	(3) Номер раствора	(4) Компоненты раствора
(11) Цинковое	(8) Сталь	1	(9) Аммоний азотнокислый Медь сернокислая Кислота соляная 1 и
(11) Кадмиевое	(12) Сталь, медь и ее сплавы	2	(13) Аммоний азотнокислый Кислота соляная 1 и
(15) Медное	(16) Сталь	3	(24) Железо хлорное Медь сернокислая
	Цинковый сплав (17)		
	Никель (18)		
Никелевое (20)	Сталь (16) Медь и ее сплавы (19)		
Хромовое (21)	Никель (18) Сталь (8)	4	(25) Кислота соляная (плотность 1,19) Кислота серная (плотность 1,84) Железо хлорное Медь сернокислая Спирт этиловый
Серебряное (22)	(27) Медь и ее сплавы, никель	5	(26) Калий йодистый Под

Continuation of TABLE 2

Концентрация (5)		(6)
g/l г/л	mg/l мг/л	Признак окончания измерения
70 7 —	— — 70	(10) Появление розового пятна
17,5 ---	— 17,5	(14) Появление основного металла
300 100	— ---	(10) Появление розового пятна (27) Появление черного пятна (28) Появление белого пятна (10) Появление розового пятна (29) Появление розового или желтого пятна
— — 60 30 ---	220 100 — — 100	(28) Появление белого пятна (10) Появление розового пятна
250 7,5 150 — — 31	— — — 150 250 —	(14) Появление основного металла Появление черного пятна (27)

Continuation of TABLE 2

(30) Медное, сплав медь- цинк (латун- ное)	(8) Сталь	6	(31) Железо хлорное Кислота соляная (плотность 1,19) Кислота уксусная (ледяная) Сурьма треххлористая
--	--------------	---	---

KEY: (1) Type of coating (2) Base metal or metal of sublayer  
 (4) Components of solution (5) Concentration (6) End-of-test  
 indicator (7) Zinc (8) Steel (9) Ammonium nitrate Copper  
 sulfate Hydrochloric acid 1N (10) Appearance of a pink spot  
 (11) Cadmium (12) Steel, copper and its alloys (13) Ammonium  
 nitrate Hydrochloric acid 1N (14) Appearance of base metal  
 (15) Copper (16) Steel (17) Zinc alloy (18) Nickel (19)  
 Copper and its alloys (20) Nickel (21) Chromium (22) Silver  
 (23) Copper and its alloys, nickel (24) Ferric chloride  
 (25) Hydrochloric acid (density 1.19) Sulfuric acid (density  
 1.84) Ferric chloride Copper sulfate Ethyl alcohol (26)  
 Potassium iodide Iodine (27) Appearance of a black spot  
 (28) Appearance of a white spot (29) Appearance of a pink or  
 yellow spot (30) Copper, copper-zinc alloy (brass) (31) Ferric  
 chloride Hydrochloric acid (density 1.19) Acetic acid (glacial)  
 Antimony trichloride

## NOTE:

1. When determining the thickness of a chromium layer, in order  
 to disrupt the passive layer, it is necessary to touch the surface  
 of an article with a zinc rod wetted with the solution being used.

Continuation of TABLE 2

2. In the case of difficulties encountered in the determination of the end of dissolution of copper coatings on steel, a drop of 1.5% solution of antimony trichloride in hydrochloric acid (1:1) is delivered periodically from a pipet after the appearance of a shiny pink spot of the contact-precipitated copper or shortly before the dissolution of the coating (before the appearance of a dark spot). The appearance of a dark spot 2-3 s after the drop is applied indicates that the coating has been dissolved. Before the drop is applied and before the continuation of the jet test, the area to be tested is rubbed out with filter paper.



TABLE 3

(2) Температура, °C	(1) Толщина покрытия ( $H_1$ ),			
	(3) цинкового	(4) кадмиевого	(5) медного (для раствора № 3)	(6) медного (для раствора № 6)
12	0,515	0,190	0,538	0,443
13	0,530	0,195	0,568	0,470
14	0,542	0,201	0,602	0,498
15	0,560	0,207	0,641	0,526
16	0,571	0,211	0,685	0,560
17	0,589	0,217	0,735	0,594
18	0,610	0,223	0,794	0,629
19	0,630	0,229	0,862	0,664
20	0,645	0,235	0,926	0,699
21	0,670	0,241	0,980	0,734
22	0,690	0,247	1,042	0,768
23	0,715	0,253	1,099	0,802
24	0,740	0,260	1,163	0,836
25	0,752	0,265	1,220	0,870
26	0,775	0,272	1,266	—
27	0,790	0,279	1,333	—
28	0,808	0,286	1,389	—
29	0,824	0,294	1,429	—
30	0,833	0,302	1,471	—

Continuation of TABLE 3

СИНТЕЗОВАНА ЗА 1 СЕК, МММ

(6) никелевого	(7) хромового	(8) серебряного	(9) сплав медь-цинк (для раствора № 6)
0,236	—	—	—
0,262	—	—	—
0,294	—	0,320	—
0,333	0,094	0,340	0,526
0,376	0,101	0,355	0,560
0,424	0,109	0,367	0,594
0,467	0,120	0,380	0,629
0,493	0,131	0,390	0,664
0,521	0,139	0,403	0,699
0,546	0,147	0,413	0,734
0,575	0,156	0,420	0,768
0,606	0,164	0,431	0,802
0,641	0,169	0,439	0,836
0,671	0,174	0,450	0,870
0,709	—	—	—
0,741	—	—	—
0,769	—	—	—
0,800	—	—	—
0,833	—	—	—

Continuation of TABLE 3

KEY: (1) Coating thickness ( $H_t$ ) removed in 1 s, in  $\mu\text{m}$ . (2) Temperature,  $^{\circ}\text{C}$  (3) Zinc (4) Cadmium (5) Copper (for solution #3) (6) Nickel (7) Chromium (8) Silver (9) Copper-zinc alloy (for solution #6)

NOTE:

The value ( $H_t$ ) is given for the zinc coatings from cyanide, sulfate, ammoniate, and zincate electrolytes; cadmium coatings from cyanide electrolytes; copper - from sulfate (for solution #3), brass - from cyanide; nickel - from sulfate and fluoboric; silver - from cyanide and thiocyanic acid; dull chromium - from sulfate; copper - from sulfate and cyanide electrolytes (for solution #6).

Fig. 2.

Diagram of the device for  
intermittent-jet (electro-  
jet) method

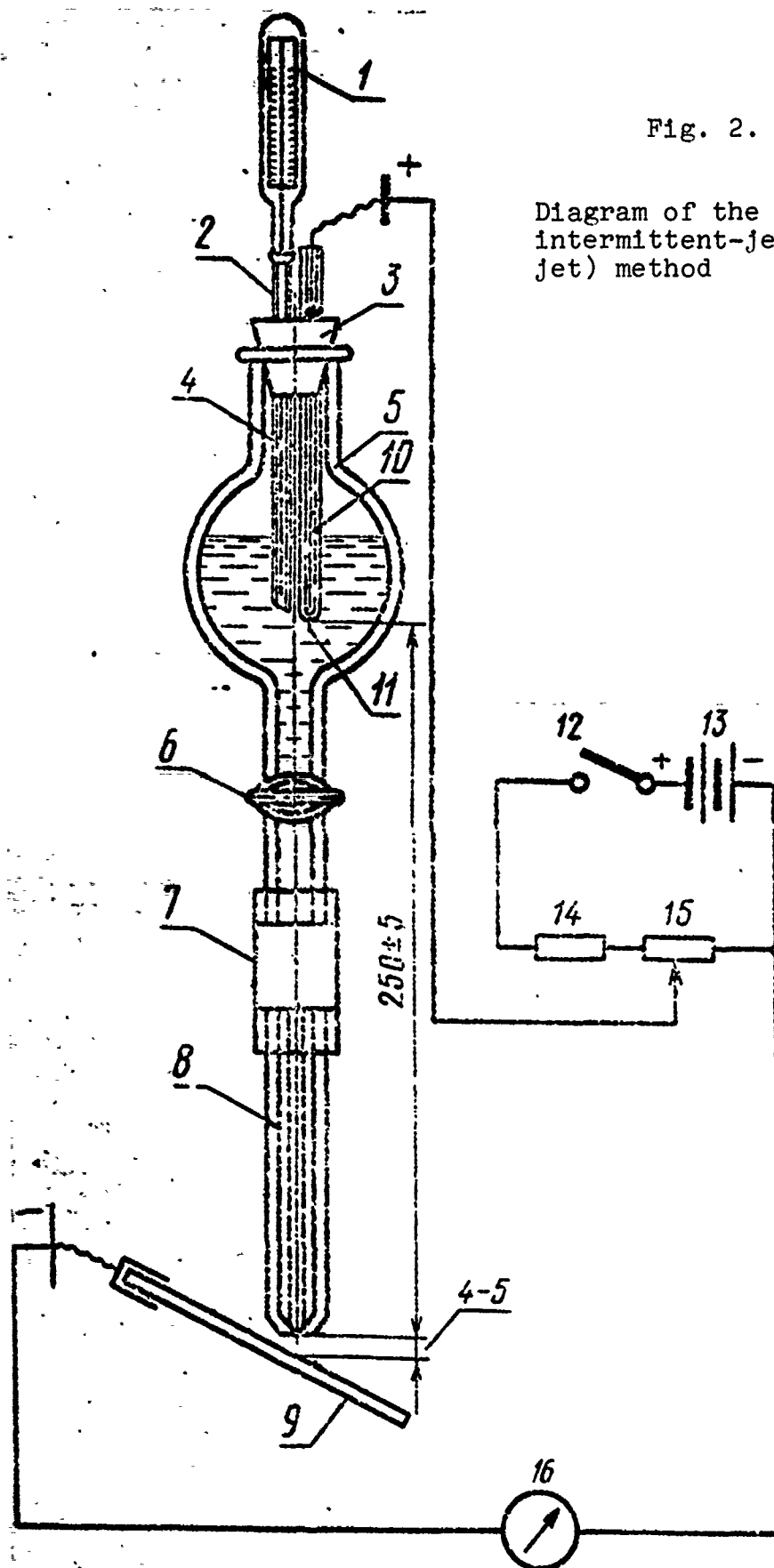


TABLE 4

(2) Интервал времени, сек	(1) Поправочные коэффициенты для покрытий из никелевых электролитов с блескообразующими добавками			
	(3) 1,4 бутиндиол	(4) Кумарин и п-толуолсульфамид	(5) 2,6-2,7-нафталиндисульфокислота и формалин	(6) 2,6-2,7-нафталиндисульфокислота
0-20	1,2	1,6	1,3	1,5
20-40	1,1	1,4	1,0	1,4
40-80	1,0	1,3	0,9	1,3
80-100	0,9	1,2	0,8	—

KEY: (1) Correction factors for coatings out of nickel electrolytes with luster-forming additives (2) Time period, s (3) 1,4 butinediol (4) Coumarin and n-toluolsulfamide (5) 2,5-2,7-naphthalinedisulfonic acid and formalin (6) 2,5-2,7-naphthalinedisulfonic acid

TABLE 5

(2) Температура, °C	(1) Толщина покрытия ( $H_V$ ), снимаемая 1 мл раствора, мкм			
	(3) цинкового	(4) кадмиевого	(5) медного	(6) никелевого
12	1,465	0,886	2,266	0,995
13	1,501	0,900	2,370	1,091
14	1,540	0,914	2,481	1,211
15	1,597	0,929	2,604	1,355
16	1,610	0,943	2,747	1,510
17	1,645	0,957	2,915	1,681
18	1,688	0,971	3,115	1,832
19	1,740	0,986	3,344	1,908
20	1,776	1,000	3,546	1,996
21	1,845	1,014	3,717	2,070
22	1,895	1,029	3,906	2,151
23	1,945	1,043	4,065	2,242
24	1,990	1,057	4,255	2,347
25	2,033	1,071	4,425	2,433
26	2,080	1,086	—	2,520
27	2,126	1,100	—	2,620
28	2,173	1,114	—	2,720
29	2,219	1,129	—	2,820
30	2,266	1,143	—	2,920

KEY: (1) Coating thickness ( $H_V$ ) removed by 1 ml of solution,  $\mu\text{m}$

(2) Temperature, °C (3) Zinc (4) Cadmium (5) Copper

(6) Nickel

NOTE:

The value ( $H_V$ ) is given for the zinc coatings from cyanide, sulfate, ammoniate, and zincate electrolytes; cadmium from cyanide; copper from sulfate, and nickel from sulfate electrolytes.

TABLE 6

(1) Вид покрытия	(2) Основной металл или металл подслоя	(3) Номер раствора	(4) Компоненты раствора
(9) Цинковое Кадмиевое	(10) Сталь, медь и ее сплавы	7	(11) Калий йодистый Йод
(13) Медное	(14) Сталь, никель	8	(15) Серебро азотнокислое
(17) Никелевое	(10) Сталь, медь и ее сплавы	9	(18) Железо хлорное Медь сернокислая
(20) Серебряное	(21) Медь и ее сплавы	10	а) Калий йодистый Йод (22) б) Натрий серноватисто- кислый (тиосульфат натрия) Вода дистиллированная
(23) Оловянное	(10) Сталь, медь и ее сплавы	11	Железо хлорное (24) Медь сернокислая Кислота соляная (плот- ность 1,19)
(25) Сплав олово-свинец (ПОС)	(10) Сталь, медь и ее сплавы	12	(26) Кислота борфтористово- дородная (плотность 1,15) Перекись водорода 30%- ная Дистиллированная вода

Continuation of TABLE 6

(5) Кон- центра- ция, г/л г/с	(6) Количество компонен- та 2-3 мл	(7) Время выдержи ки одной капли, сек	(8) Признак окончания измерения
200 100	— —	60	(12) Появление основного ме- талла
44	—	20	Появление темного пятна на стали или белого на никеле (16)
300 100	— —	30	(19) Появление розового пят- на
400 180 — —	— — 300 г 1000 мл	60 30	(12) Появление основного ме- талла
50 20 —	— — 150 мл	30	(19) Появление розового пят- на
— — —	10 мл 2,5 мл 90 мл	30	(12) Появление основного ме- талла



# KEY for TABLE 6

(1) Type of coating (2) Base metal or metal of sublayer (3) Number of solution (4) Solution components (5) Concentration, g/l (6) Amount of the component (7) Time (seconds) the drop is left on the surface (8) End-of-measurement indicator (9) Zinc Cadmium (10) Steel, copper and its alloys (11) Potassium iodide Iodine (12) Appearance of base metal (13) Copper (14) Steel, nickel (15) Silver nitrate (16) Appearance of a dark spot on steel or a white spot on nickel (17) Nickel (18) Ferric chloride Copper sulfate (19) Appearance of a pink spot (20) Silver (21) Copper and its alloys (22) a) Potassium iodide Iodine b) Potassium thiosulfate Distilled water (23) Tin (24) Ferric chloride Copper sulfate Hydrochloric acid (density 1.19) (25) Tin-lead alloy (POS) (26) Fluoroboric acid (density 1.15) Hydrogen peroxide 30% Distilled water

## NOTE:

When testing the thickness of silver coatings, a drop of solution a is applied to the coating and left there for 60 s, after which, it is removed with a filter paper and a drop of solution b is placed in the same spot, which is left there for 30 s and then blotted with filter paper. This procedure is continued until the base metal or a metal sublayer shows through. When calculating the coating thickness, only the number of drops of solution a is taken into account, since solution b is a supplementary solution used to eliminate the silver iodide formed in the process of silver dissolution.

TABLE 7

(2) Температура, °C	Толщина покрытия ( $H_k$ ), снимаемая за указанное время одной каплей, мкм				
	(3)	(4)	(5)	(6) сплав олово-свинец	
	цинкового 60 с ч.	медного 30 с к	никелевого 30 с	ПОС40 30 с	ПОС61 30 с к
12	0,87	0,83	0,55	0,68	0,53
13	0,91	0,85	0,57	0,70	0,54
14	0,96	0,87	0,59	0,72	0,55
15	1,01	0,89	0,61	0,73	0,56
16	1,05	0,93	0,63	0,75	0,57
17	1,09	0,97	0,65	0,77	0,57
18	1,14	1,01	0,67	0,79	0,58
19	1,18	1,05	0,69	0,81	0,58
20	1,24	1,08	0,70	0,83	0,59
21	1,27	1,11	0,71	0,84	0,60
22	1,32	1,14	0,72	0,86	0,60
23	1,36	1,16	0,73	0,88	0,61
24	1,40	1,18	0,74	0,90	0,62
25	1,45	1,20	0,75	0,92	0,63
26	1,52	1,21	—	0,94	0,63
27	1,59	1,23	—	0,96	0,64
28	1,66	1,24	—	0,97	0,65
29	1,73	1,25	—	0,99	0,65
30	1,80	1,26	—	1,03	0,66

KEY: (1) Coating thickness ( $H_k$ ) removed in the given time by one drop,  $\mu\text{m}$  (2) Temperature, °C (3) Zinc (4) Copper (5) Nickel (6) Tin-lead alloy

## NOTE:

1. For the cadmium coating, the value ( $H_k$ ), removed in 30 s at 12–30°C, is equal to 1.2; for the tin coating this value, at the same time and temperature, is 0.55; and for the silver coating, at 18–25°C and for 30 s, this value is equal to 1.10.

2. The value ( $H_k$ ) is given for the nickel coatings from sulfate electrolytes; copper coatings from the sulfate and cyanide electrolytes; zinc coatings from the ammoniate and cyanide electrolytes; cadmium coatings from the sulfate and cyanide electrolytes; tin coatings from the acid and alkali electrolytes; silver coatings from cyanide and thiocyanic acid electrolytes; tin-lead alloy from fluoroboric electrolytes.

3. When the thickness of nickel coating is less than 3  $\mu\text{m}$ , a drop of a solution is left for 15 s.. At 18°C one drop removes 0.3  $\mu\text{m}$  of nickel in 15 s.

TABLE 8

(1) Вид покрытия	(2) Основной металл или металл подслоя	(3) Номер раствора	(4) Компоненты раствора
(9) Цинковое	(10) Сталь	13	(11) Кислота серная (плот- ность 1,84) Кислота соляная (плот- ность 1,19)
(13) Кадмиевое	(10) Сталь	14	(14) Аммоний азотнокислый
(16) Медное	(10) Сталь	15	(17) Ангидрид хромовый Аммоний сернокислый
(18) Никелевое	(10) Сталь	16	Аммоний азотнокислый Кислота уксусная (ледя- ная) (19)
(21) Хромовое	(22) Никель, медь и ее сплавы	17	Кислота соляная (плот- ность 1,19) (23) Вода дистиллированная
(21) Хромовое	(10) Сталь	18	Кислота соляная (плот- ность 1,19) (25) Трехокись сурьмы
(26) Серебряное	(27) Сталь, медь и ее сплавы	19	Кислота азотная (плот- ность 1,41) (28) Кислота серная (плот- ность 1,84)

Cont. of TABLE 8

(5) Концентрация, %	(6) Количество компонента	(7) Температура раствора, °C	(8) Способ определения
50	—	18—25	(12) По разности масс
17	—		
—	(15) Насыщенный раствор	18—25	(12) По разности масс
275	—	18—25	(12) По разности масс
110	—		
100	—		
—	2 мл мл = гр	70—80	(20) Химический анализ на никель
—	1 объемная часть (24)	20—40	(12) По разности масс
—	1 объемная часть		
366	—	18—25	(12) По разности масс
20	—		
—	1 (24) объемная часть	18—25	(30) Химический анализ на серебро
—	9 объемных частей (29)		

Cont. of TABLE 8

Вид покрытия	Основной металл или металл подслоя	Номер раствора	Компоненты раствора
(31) Оловянное, сплав олово-свинец, свинцовое	(10) Сталь	20	(32) Кислота борфтористоводородная (плотность 1,15) Перекись водорода (30%-ная) Вода дистиллированная
(33) Сплав медь-цинк (латунное)	(10) Сталь	21	(17) Ангидрид хромовый Аммоний сернистый
(34) Сплав олово-медь («белая бронза» — 40%)	(10) Сталь	22	Кислота винная (50%-ная) (35) Кислота азотная (плотность 1,41)
(36) Оловянное	Омедненная сталь, медь и ее сплавы (37)	23	(38) Свинец уксуснокислый Натр едкий
(40) Свинцовое	(41) Омедненная сталь	24	Кислота сульфаминная Перекись водорода (30%-ная) (42) Вода дистиллированная
(43) Окисное	(44) Алюминий и его сплавы	25	Кислота (45) фосфорная (плотность 1,68) Ангидрид хромовый

Cont. of TABLE 8

Концен- трация, г/л	Количество компонента	Темпера- тура рас- твора, °C	Способ определения
—	10 мл	18—25	(12) По разности масс
—	2,5 мл		
—	90 мл		
275 110	— —	18—25	(12) По разности масс
—	3 объемные части (24)	18—25	(12) По разности масс
—	1 объемная часть		
80 135	— —	(39) Кипения	(12) По разности масс
150 —	— 50 мл	50—70	(12) По разности масс
—	1000 мл		
52 20	— —	90—100	(12) По разности масс

KEY FOR TABLE 8:

(1) Type of coating (2) Base metal or metal of sublayer (3) Number of solution (4) Solution components (5) Concentration, g/l (6) Amount of component (7) Temperature of solution, °C (8) Method of determination (9) Zinc (10) Steel (11) Sulfuric acid (density 1.84) Hydrochloric acid (density 1.19) (12) Using the difference of masses (13) Cadmium (14) Ammonium nitrate (15) Saturated solution (16) Copper (17) Chromium anhydride (18) Nickel (19) Ammonium nitrate Acetic acid (glacial) (20) Chemical analysis for nickel (21) Chromium (22) Nickel, copper and its alloys (23) Hydrochloric acid (density 1.19) Distilled water (24) 1 volumetric part (25) Hydrochloric acid (density 1.19) Antimony trioxide (26) Silver (27) Steel, copper and its alloys (28) Nitric acid (density 1.41) Sulfuric acid (density 1.84) (29) 9 volume parts (30) Chemical analysis for silver (31) Tin, tin-lead alloy, lead (32) Fluoroboric acid (density 1.15) Hydrogen peroxide (30%) Distilled water (33) Copper-zinc alloy (brass) (34) Tin-copper alloy ("white bronze" -40%) (35) Tartaric acid (50%) Nitric acid (density 1.41) (36) Tin (37) Copper-plated steel, copper and its alloys (38) Lead acetate Sodium hydroxide (39) Boiling (40) Lead (41) Copper-plated steel (42) Sulfamic acid Hydrogen peroxide (30%) Distilled water (43) Oxide (44) Aluminum and its alloys (45) Phosphoric acid (density 1.68)

NOTE:

1. The solution #23 dissolves only the layer of pure tin; ferrostannous alloy obtained by the diffusion of tin into iron during fusion in glycerine, does not dissolve.

2. The density of the oxide-aluminum film is  $3.42 \text{ g/cm}^3$ .

TABLE 9

(1) Основной металл	(2) Покрытие	(3) Компоненты пасты	(4) Признак окончания определения
(5) Сталь	(6) Все виды покрытий	(7) α-α-дипиридил или О-фенантролин Соляная кислота Двуокись титана	(8) Красное окрашивание
(9) Медь и ее сплавы	(10) Все виды покрытий, кроме цинкового и кадмиевого	(11) Состав № 1 Дифенилкарбазид Кислота уксусная Аммоний надсернокислый Глицерин Двуокись титана	(12) Красно-коричневое окрашивание
		(13) Состав № 2 Кадмон II (динатриевая соль n-нитродиазоаминоазобензол-дисульфокислоты) Аммоний Аммиак Двуокись титана	(13) Красное окрашивание
(14) Цинк и его сплавы	(15) Все виды покрытий	(16) Дифенилкарбазид Едкий натр Пропиловый или этиловый спирт Двуокись титана	(17) Розово-лиловое окрашивание
(18) Алюминий и его сплавы	(15) Все виды покрытий	(19) Алюминий (аммониевая соль ауриитрикарбоновой кислоты) Перекись водорода Двуокись титана	(20) Розовое окрашивание

KEY: (1) Base metal (2) Coating (3) Paste components (4) End-of-test indicator (5) Steel (6) All types of coatings (7) α-α-dipyridyl or O-phenanthroline Hydrochloric acid Titanium dioxide (8) Red color (9) Copper and its alloys (10) All types of coatings, except zinc and cadmium (11) Composition #1 Diphenylcarbazide Acetic acid Ammonium persulfate Glycerine Titanium dioxide (12) Red-brown color (13) Composition #2 Cadmon II (disodium salt of n-nitrodiazoaminoazo-



benzinedisulfoacid) Ammonium Ammonia Titanium dioxide  
(14) Zinc and its alloys (15) All types of coatings (16)  
Diphenylthiocarbazide Sodium hydroxide Propyl or ethyl al-  
cohol Titanium dioxide (17) Pink-lilac color (18) Aluminum  
and its alloys (19) Aluminon (ammonium salt of the aurin-  
tricarboxic acid) Hydrogen peroxide Titanium dioxide (20)  
Pink color

NOTE:

Composition #1 is not applicable for determining the porosity  
of tin coatings and the coatings by its alloys.

TABLE 10

(1) Вид покрытия	(2) Основной металл или металл подслоя	(3) Номер раствора	(4) Компоненты раствора
(8) Хромовое одно- слойное и много- слойное (никель- хром, медь-никель- хром)	(9) Сталь	26	(10) Калий железосинхро- дистый Аммоний хлористый Натрий хлористый
(12) Хромовое одно- слойное и много- слойное (никель- хром)	(13) Медь и ее сплавы		
(14) Никелевое одно- слойное	(9) Сталь	27	(20) Калий железосинхро- дистый Натрий хлористый
	(13) Медь и ее сплавы		
(17) Никелевое мно- гослойное (медь- никель, никель- медь-никель)	(9) Сталь		
(18) Медное	(9) Сталь		
(19) Оловянное	(9) Сталь	28	(20) Калий железосинхро- дистый Натрий хлористый

Cont. of TABLE 10

(5) Концентра- ция, г/л	(6) Время выдер- жки раствора, мин	(7) Признак пористости
10 30 60	10	(11) Синие точки — поры до стали. Красно-бурые точки — поры до меди. Желтые точки — по- ры до никеля
10 20	5	(15) Синие точки — поры до стали
	10	(16) Красно-бурые точки — поры до меди
	10	Синие точки — поры до стали. (11) Красно-бурые точки — поры до меди. Желтые точки — поры до никеля
	20	(15) Синие точки — поры до стали
10 5	60	(15) Синие точки — поры до стали

KEY FOR TABLE 10:

- (1) Type of coating (2) Base metal or metal of sublayer  
(3) Number of solution (4) Solution components (5) Concentration, g/l (6) Time the solution is left on, in min (7) Sign of porosity (8) Single-layer and multilayer chromium (nickel-chromium, copper-nickel-chromium) (9) Steel (10) Potassium ferricyanide Ammonium chloride Sodium chloride  
(11) Blue spots - pores extending to steel. Dark-red spots - pores extending to copper. Yellow spots - pores extending to nickel (12) Single-layer and multilayer chromium (nickel-chromium) (13) Copper and its alloys (14) Single-layer nickel (15) Blue spots - pores extending to steel (16) Dark-red spots - pores extending to copper (17) Multilayer nickel (copper-nickel, nickel-copper-nickel) (18) Copper (19) Tin  
(20) Potassium ferricyanide Sodium chloride

TABLE 12

(1) Вид покрытия	(2) Номер раствора	(3) Основной металл или металла подслоя	(4) Компоненты раствора	(5) Концентра- ция	(6) Время вы- держки, мин
(7) Окисное химическое	29	(8) Сталь	(9) Медь сернокислая	20 г/л 2/л	0,5
(10) Окисное анодиза- ционное	30	(11) Алюми- ний и его сплавы	(12) Кислота соляная (плотность 1,19) Калий двуххромовокислый Вода дистиллированная	25 мл 3 г 75 мл мл	2—20 — —
(13) Фосфат- ное	31	(14) Сталь, медь серно- кислая	Медь сернокислая (15) Кислота соляная 0,1 н Натрий хлористый	82 г/л 13 мл/л 33 г/л	2 и (16) более
	32		(17) Натрий хлористый	30 г/л	15
	33		(17) Натрий хлористый	10 г/л	5

KEY: (1) Type of coating (2) Number of solution (3) Base metal or metal of sublayer (4) Components of solution (5) Concentration (6) Time, min (7) Oxide, chemical (8) Steel (9) Copper sulfate (10) Oxide, anodized (11) Aluminum and its alloys (12) Hydrochloric acid (density 1.19) Potassium bichromate Distilled water (13) Phosphatate (14) Steel, copper sulfate (15) Copper sulfate Hydrochloric acid 0.1N Sodium chloride (16) 2 and more (17) Sodium chloride

TABLE 13

(1) Электролиты анодного окисления	(2) Состояние материала	(3) Нормы времени контроля при темпе- ратурах, °C, не менее, мин				
		11-13	14-17	18-21	22-26	27-32
(4) Серная кислота	(5) Плакированный с толщиной покрытия 5 мкм	20	15	12	8	7
	(6) Плакированный с толщиной покрытия 10 мкм Лист 0,8 мм без утолщенной плакировки	23	18	15	12	10
	(7) Лист 0,8 мм и лист 0,8 мм с утолщенной плакировкой	30	25	20	17	14
(4) Серная кис- лота	(8) Неплакированный наполнен- ный хромпиком с толщиной покрытия 5 мкм	8	6	3	2	1
(9) Хромовая кислота	(10) Плакированный	—	—	6	4	3
	(11) Неплакированный	—	—	3	2	1

KEY: (1) Anode-oxidation electrolytes (2) State of material (3) Time-control norms at temperatures, °C, at least, in min (4) Sulfuric acid (5) Plated with the coating thickness of 5  $\mu$ m (6) Plated with the coating thickness of 10  $\mu$ m Sheet 0.8 mm without thickened plating (7) Sheet 0.8 mm and sheet 0.8 mm with thickened plating (8) Nonplated filled dichromate with the coating thickness of 5  $\mu$ m (9) Chromic acid (10) Plated (11) Nonplated

# SOLUTIONS USED FOR ETCHING THE MICROSECTIONS

(1) Вид покрытия	(2) Основной металл или металла подслоя	(3) Наименование компонентов раствора	(4) Количество компонента	(5) Протрав- ляемый металл
(6) Цинковое, кадмиевое, никелевое	(7) Сталь Цинк и его сплавы	(8) Ангидрид хромовый Натрий сернокислый	200 г/л 15 г/л г/л	(9) Кадмий и цинк
(10) Никелевое	(11) Медь и ее сплавы, медный подслой на стали, цинке и его сплавах	(12) Аммиак водный, плот- ностью 0,9 Перекись водорода 3%-ная	объемная часть 1 (13) объемная часть	(14) Медь
(15) Никеле- вое, хромо- вое	(16) Сталь	(17) Кислота азотная, плот- ностью 1,41 Спирт этиловый	5 мл 95 мл	Сталь (16)
(18) Никеле- вое, медное, серебряное	(19) Алюминий	(20) Кислота фтористово- дородная, плотностью 0,987 Вода дистиллирован- ная	0,5 мл 99,5 мл	Алюми- ний (21)
(22) Серебря- ное	(23) Сталь, медь и ее сплавы	Аммиак водный, плот- ностью 0,9 Перекись (24) водорода 3%-ная Вода дистиллирован- ная	60 мл 15 мл 25 мл	Сереб- ро (25)
(26) Оловян- ное	(16) Сталь	(27) Кислота пикриновая Спирт этиловый	4 г 96 г	(16) Сталь
	(29) Медь и ее сплавы	(12) Аммиак водный плот- ностью 0,9 Перекись водорода 3%-ная	1 объемная часть (13) объемная часть	(28) Медь
(30) Свинцо- вое	(16) Сталь	(31) Железо хлорное Кислота соляная, плот- ностью 1,19 Вода дистиллирован- ная	10 г 2 мл 95 мл	(16) Сталь

KEY: (1) Type of coating (2) Base metal or metal of sublayer (3) Components of solution (4) Number of components (5) Etched metal (6) Zinc, cadmium, nickel (7) Steel Zinc and its alloys (8) Chromic anhydride Sodium sulfate (9) Cadmium and zinc (10) Nickel (11) Copper and its alloys, copper sublayer on steel, zinc and its alloys (12) Hydrous ammonia with 0.9 density Hydrogen peroxide 3% (13) volume part (14) Copper (15) Nickel, chromium (16) Steel (17) Nitric acid at 1.41

density Ethyl alcohol (18) Nickel, copper, silver (19) aluminum  
(20) Hydrofluoric acid at 0.987 density Ethyl alcohol (21) Aluminum  
(22) Silver (23) Steel, copper, and its alloys (24) Hydrous ammonia  
at 0.9 density 3% hydrogen peroxide Distilled water (25) Silver  
(26) Tin (27) Picric acid Ethyl alcohol (28) Copper (29) Copper  
and its alloys (30) Lead (31) Ferric chloride Hydrochloric acid  
at 1.19 density Distilled water



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